

# HOT DRY ROCK: AN UNTAPPED SUSTAINABLE ENERGY RESOURCE

by

Gladys Hooper, Geothermal Program Manager, U.S. Department of Energy

and

Dave Duchane, Hot Dry Rock Program Manager, Los Alamos National Laboratory

## Introduction

The geothermal energy in hot dry rock (HDR) is a renewable resource that can contribute significantly to the world's sustainable and diversified energy mix in the 21st century. Geothermal energy is the natural heat of the earth. Heat at temperatures high enough to be useful is typically stored in rock at depths of 1600 meters or more underground. In a few places, the hot rock is in contact with water that can transport its heat to the surface. Hot springs and geysers are natural manifestations of geothermal heat. For decades, people have drilled into natural hydrothermal reservoirs and brought the fluid to the surface for direct use or to produce electricity. Unfortunately, there are a limited number of these hydrothermal regions. In contrast, HDR resources are plentiful at depths that can be reached by conventional drilling techniques, but they are not naturally in contact with the mobile fluids that could transport heat to the surface.

During the past 25 years, researchers have developed a method for recovering the heat from HDR resources. It involves drilling an injection well into the HDR and pumping down highly pressurized water to open natural fractures in the hot rock. This process creates a man-made geothermal reservoir of fractured rock. One or more additional wells is then drilled to intersect the engineered reservoir. The system is operated by injecting water into one wellbore, circulating the water through the man-made reservoir where it is heated, and extracting superheated water at the production wellbores (see Figure 1). After its thermal energy is extracted, the same water can be recirculated to remove more heat from the HDR. An HDR plant operated in such a closed-loop fashion is virtually pollution free and sustainable.

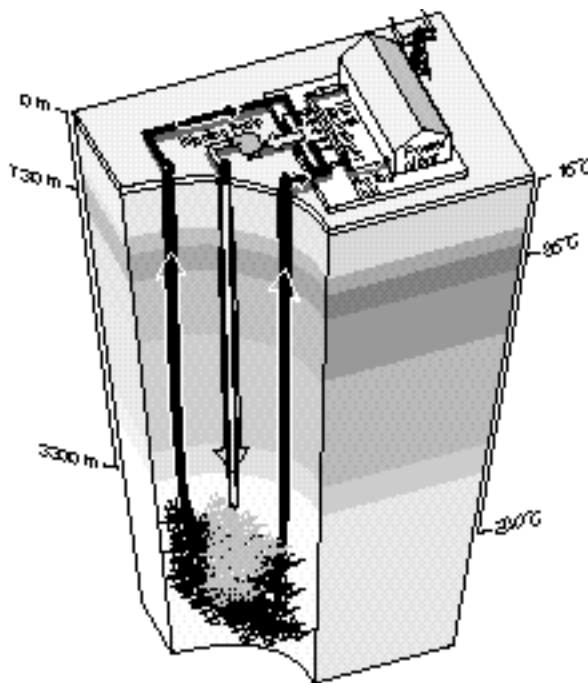


Figure 1. Diagram of a prospective HDR plant. Water circulates in a closed-loop to remove the heat of the earth.

Significant technical challenges are encountered in understanding the formation of an HDR reservoir, verifying its position and dimensions, and extracting heat from it on a sustained basis. However, the global distribution and size of HDR resources make these challenges well worth pursuing. For example, considering only high grade HDR resources, it has been calculated that the amount of thermal energy stored in the earth at temperatures high enough for uses such as electricity production (greater than 125°C) and at reachable depths (less than 10 km) is on the order of 35 million quads. The exploitation of even a small fraction of this resource base could provide all the energy the world will need for centuries.

Geothermal gradient (the rate at which temperature increases with depth) is the key factor in determining the accessibility of HDR resources. The higher the gradient, the shallower the depth at which HDR energy can be tapped and the cheaper the cost.

### **The U. S. Hot Dry Rock Program to Date**

In the United States, the Department of Energy (DOE) has supported development of HDR geothermal energy technology for over 20 years, largely under the technical auspices of Los Alamos National Laboratory (LANL) in Los Alamos, New Mexico. During that period, researchers successfully demonstrated the technical feasibility of extracting energy from HDR in a number of flow experiments conducted since 1977 at Fenton Hill, New Mexico. These experiments culminated with eight months of testing in 1992-1993, in which steady, uniform heat production was generated at a level of 4 thermal megawatts from a single production well. In 1995, researchers at LANL were able to re-establish these production levels at the same location after a hiatus of two years. They also demonstrated that the energy production from an HDR plant could be rapidly increased to more than 60% above its baseload output in order to meet short-term peak power demands.

During the early to mid-1980s, under an International Energy Agency (IEA) agreement, the governments of the Federal Republic of Germany and Japan participated directly in the Fenton Hill field experiments. Their participation involved both financial support and the assignment of scientists and engineers to the HDR staff at Los Alamos.

Supporting research on HDR resource assessment, high-temperature wellbore instrumentation and equipment, seismic technology for geothermal reservoir assessment, and reservoir performance modeling were also an integral part of the early HDR program. Several spin-off developments of HDR work (i.e., drilling and coring bits, downhole motors, and seismic techniques) are being applied now in the oil and gas industries as well as in the conventional hydrothermal geothermal industry.

The success of the Fenton Hill experiments led the DOE to issue a competitive solicitation seeking applicants to deploy the first commercial prototype HDR facility. Although bids were received from commercial organizations, the DOE found it necessary to cancel the solicitation in October 1995.

This decision should not be interpreted as a lack of U.S. support for HDR technology. Rather, the DOE has decided to advance HDR by integrating it into the mainstream of geothermal resource development. Consequently, the DOE has begun the process of restructuring its HDR program to include greater involvement by the conventional geothermal industry in a wide range of problems affecting HDR technology. The DOE believes the refocused HDR program will ensure that HDR technology makes a sizable impact on domestic energy markets in the coming decades.

### **Future U.S. Hot Dry Rock Program**

In December 1995, at the behest of the DOE, a geothermal industry panel reviewed the status of HDR work around the world and made recommendations on the future direction of the United States program. In general, the panel reaffirmed the importance of HDR to the future of the geothermal industry, suggested that HDR technology should be integrated into the conventional geothermal industry, and proposed that the name "Hot Dry Rock" be replaced with a new term that would encompass all geothermal resources requiring

artificial measures beyond current technology to achieve commercial heat extraction. Plans are already underway to implement the panel's recommendations and discussions have begun with the geothermal industry to determine future HDR work.

The DOE plans to:

- issue a Program Announcement to solicit proposals from stakeholders for projects that would help advance the state-of-the-art of HDR technology;
- participate in two or more tasks under the HDR part of a proposed International Energy Agency Agreement on geothermal energy;
- decommission the Fenton Hill hot dry rock site, or transfer it to another operator, if possible;
- issue a final report, archiving the Fenton Hill experience for use by interested stakeholders; and
- develop a five year plan for technology improvements needed by the industry to improve their confidence in HDR technology.

In summary, the United States is committed to bringing HDR technology into the marketplace as a viable energy option. The HDR resource is virtually unlimited and it has been shown that HDR energy can be extracted with no emissions of greenhouse gases or other adverse environmental effects. In addition, when proven to be commercially viable, HDR technology will be adaptable to small power plant applications in remote locations. Finally, HDR can make very substantial contributions to the world's sustainable energy economy in the next century.